Providing a context-aware location based web service through semantics and user-defined rules

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ABSTRACT
In this paper, the design and the implementation of a novel context-aware location based service is presented, called “Geo SPLIS/ Geographic Semantic Personalized Location Information System”. Geo SPLIS offers users the capability to add their own contextualized preferences regarding Points of Interests (POIs) and combines them with POI owners group targeted offers to deliver high quality personalized information. In order to achieve this, the presented system a) collects data from external sources such as Google Places API, POIs’ websites and Google+, b) adopts the schema.org ontology to represent people and places profiles, c) provides a user friendly web editor for adding rules at run time, d) uses RuleML and Jess compatible rules to model user preferences and group-targeted place offers and make them machine executable, e) stores data and rules in the Sesame RDF triple store and f) evaluates these data and rules on-the-fly so as to deliver POIs and offers matching user context, presented on Google Maps. Geo SPLIS aims to address some issues regarding knowledge-based personalization in location based services and provide a collaborative knowledge creation platform for other systems in the web.

Categories and Subject Descriptors
1.2 [ARTIFICIAL INTELLIGENCE]: Applications and Expert Systems, Computer Applications, General

General Terms

Keywords
Semantic Web, Ontologies, Rules, Context, Location Based Services, Points of Interest, Preferences, Group-Targeted Offers.

1. INTRODUCTION
Software technologies (operating systems, semantic web standards, available API’s etc.) combined with recent advances in hardware technologies related to mobile devices (GPS, sensors and other capabilities) contributed to the commercialization of a new type of services called Location Based Services (LBS) [1, 2]. LBS are typically applications that utilize user position and they are used daily by millions of people in many sectors of every day life such as [3, 4]:

a) Information (e.g. spotting nearby places, information concerning local news or weather)

b) Communication (e.g. spotting nearby friends)

c) Marketing (e.g. nearby offers or coupons)

d) Entertainment (e.g. location based games)

e) Navigation/Driver assistance (e.g. finding shortest route, finding parking spots)

f) Tracking/safety (e.g. fleet management, tracking children or pets, emergency calls)

LBS consumers’ requirements are closely related to their profile (e.g. preferences, emotional states, social state etc.) and their environment (location, day, time, weather, relationships, companion, traffic situations etc.), usually referred as context [5-6]. Context awareness enables proactive personalized information of higher quality and consequently leads to better user engagement and commercial success. Collecting, sharing, and acquiring contextual data is a challenge for the scientific community and therefore they focus on evolving relevant hardware structures such as GPS, sensors and semantic web software technologies such as ontologies and rules [5-8].

Concerning the second domain referred above, semantic web standards such as RDF/S and OWL (usually referred as ontologies), improved context awareness due to the following reasons [7-9]:

a) They offer the ability to model complex contextual situations by representing the structure of physical entities and the connections between them. For instance, they are widely used for representing concepts such as persons’ profiles, places etc.

b) They enable knowledge sharing and interoperability among heterogeneous systems in the web by providing a formal representation standard. Connecting and sharing data from various sources (people, places), enables applications that operate on a global data layer.

c) They provide flexibility, since they can be reused and extended easily, saving a lot of time and effort for developers.

Ontologies often require extensive reasoning capabilities and increased expressiveness. Therefore, they combined with rule-based technologies. Rule-based systems are more autonomous due to the following reasons [9, 10]:

a) They are capable of conceiving context changes and respond accordingly without user intervention.
b) They are more proactive and have the capability to offer services in advance.

Various efforts have been made to combine ontologies and rules. Two of the most popular are:

a) OWL 2 RL [11], which is an intersection of Description Logic and Horn Logic

b) SWRL [12], which is a union of Description Logic and Horn Logic, namely OWL and RuleML, extending the expressiveness of both of them.

In this work, an innovative location based service called “Geo SPLIS” (SPLIS stands for “Semantic Personalized Location Information System”) is presented in order to deal with some drawbacks regarding knowledge based personalization in LBS and provide high level contextualized information. Geo SPLIS is a collaborative knowledge creation platform which offers users the capability to add their own contextualized rule based preferences (concerning POIs) through a user friendly web editor (e.g. “If time is between 12:00-16:00 and the day is Saturday then I would like to go to a Restaurant which is closer than 1000 meters”). Data collected from forms are being transformed into RuleML and then into Jess so as to be machine understandable. After that, all data and rules are stored in the Sesame RDF triple store in order to be shared with other systems in the web. Geo SPLIS is built on top of our previous work called “SPLIS” [13] in order to combine user defined preferences with POI owners’ group targeted offers. In detail, POI owners are able to assert their own properties and group targeted offers (through a similar web interface), which are then represented as rules (for example the rule “If user is unemployed and the day is Friday then espresso price has a 10% discount”). When a user is logged into the system, it evaluates data and rules on the fly and offers customized and contextualized information presented on Google Maps.

In the following section, research relevant to the areas of the present work is presented. Section 3 describes the design and the implementation details of Geo SPLIS, while in Section 4 the operation process is discussed. In Section 5 some use case scenarios are presented. Finally, Section 6 demonstrates the evaluation results and section 7 presents the conclusions of our work and discusses future directions.

2. RELATED WORK
Various approaches use semantic web technologies to provide personalized information. Some of them that inspired our work are the following:

2.1 Semantic-based personalization in LBS
Ciaramella et al. [14] implemented an application which proposes a set of available services to a user, determining his/her situation by utilizing predefined rules in SWRL format. A novel interface is implemented by Wilson et al. [15] to provide user personalized information. Instead of forcing user making continuing complex queries, the service finds relations between semantically annotated data and displays relevant information in advance. Furthermore, Niforatos et al. [16] proposed a service which displays (proactively) nearby offers while he/she is on the move. Keßler et al. [17] proposed a RESTful approach for SWRL rule editing in a mobile service which recommends personalized surf spots at California’s central coast. Another rule based LBS is Sem-Fit [18], which exploits fuzzy rules for hotel recommendation. A user is able to provide an evaluation of the returning results and Sem-Fit updates the rules in order to improve the results. Armenazoglou et al. [19] implemented a conference assistant service which utilizes Semantic Web technologies to deliver contextualized notifications to conference attendees.

2.1.1 Semantic-based LBS that utilize social media data
Multiple services make use of social media data to achieve better personalization. An example is PhotoMap [20], which exploits rules in SWRL format to attach physical and social context to photo shots (for example where the photo was taken and who was there). Furthermore, an interface for photo managing is supported. Serrano et al. [21] combined RDF data taken from sources such as foaf profile with predefined rules in SWRL format to recommend places of interest related to users’ profiles. Li et al. [22] propose a semantic-based mobile ad hoc social network which uses a semantics-aware discovery mechanism to locate users with similar interests. Croitoru et al. [23] presents a system prototype for harvesting, processing, modelling, and integrating heterogeneous social media feeds towards the generation of geosocial knowledge.

2.2 Geo SPLIS relation to other works and overall contribution
Geo SPLIS combines many of the advantages of the related works described above with some additional features to provide high quality contextualized information. Geo SPLIS contribution could be summarized in the following:

a) It is fully compatible with a popular and innovative ontology such as schema.org 4 (also adopted by Google, Bing and Yahoo) and incorporates dynamically its RDF Schema version. Schema.org ontology offers the capability to represent a wide range of physical and digital entities (persons, places, movies etc.), and also the connections between them. A consistently used and widely accepted ontology such as the above is necessary for the acceptance of the system by end users and the re-usability of its data and knowledge.

b) Addresses a major drawback of knowledge based systems, such as the “limited set of rules”. Rule based systems are useful when enough amounts of web usage data are available and a disadvantage of the rule-based systems which were referred above is that they use a predefined set of rules manually created by the developers [24, 25]. These rules cannot describe every possible situation for every user and meet his/her requirements at any time [24, 25]. Geo SPLIS deals with this problem by providing an intuitive user-oriented interface letting non technical users add rules at run time. Instead of having problems and becoming obsolete Geo SPLIS becomes more and more intelligent as soon as more rules are inserted into the system.

c) Deals with the disadvantage of laborious rule creation. Specifically, design, implementation and maintenance of new rules is a time consuming process which requires a lot of

1 Can be accessed at http://tinyurl.com/GeoSPLIS
3 https://maps.google.com/
4 http://schema.org/
developers capabe of exposing their preferences by authoring rules. Preferences and provide proactive, customized and contextualized Geo SPLIS general idea is to model and evaluate such kind of morning 

morning and weather is sunny I would like to go to a coffee shop” or “if it is afternoon, I would like some restaurants that serve Italian cuisine” etc., which depend on his/her current situation. Such preferences are not completely random and present strong

d) As soon as users take part in the knowledge construction process, their rules are more consistent, qualitative and efficient than those of the developers and they can provide customized information of higher quality [14, 17].

3 DESIGN AND IMPLEMENTATION

In everyday life, people have preferences such as “if it is Saturday morning and weather is sunny I would like to go to a coffee shop” or “if it is afternoon, I would like some restaurants that serve Italian cuisine” etc., which depend on his/her current situation. Such preferences are not completely random and present strong daily patterns [26]. For example, a user usually visits a beach when weather is hot, a bar when it is night, or a museum if it is morning [26].

Geo SPLIS general idea is to model and evaluate such kind of preferences and provide proactive, customized and contextualized information to each user. As it was mentioned above, regular users are capable of exposing their preferences by authoring rules that represent them, through a user-friendly web editor. After that, every time a user is inserted into the system, Geo SPLIS gets his/her context (profile, weather, location, day and time), evaluates both his/her rule-based preferences and also POI owners’ rules and finally delivers personalized information. Geo SPLIS is able to handle rules that involve:

a) every existing property of a POI
b) weather (e.g. if weather is Sunny find me an ice-cream shop)
c) time-day-month (e.g. I would like to visit a restaurant which serves Italian cuisine, if it is Friday between 19:00-21:00)
d) user’s location (e.g. I want a grocery store which is closer than 900 meters away)

Concerning system implementation, a variety of software technologies were combined for this purpose. To begin with, Sesame [27] is used as a storage/retrieval component. It is consistently used for RDF data manipulation supporting operations such as storing and querying triples.

Additionally, in order to implement a rule-based system such as Geo SPLIS, a rule representation language is needed in order to transform human understandable policies into machine comprehensible rules. RuleML (and more specific Reaction RuleML) was chosen for this purpose, due to the following reasons [28, 29]:

a) It is a powerful markup language (XML with a predefined schema) and supports various types of rules such as deductive, reactive and normative.
b) It provides interoperability among various systems on the web, by allowing rules to be represented in a formal way.
c) A user-friendly interface can be implemented, as it is close to natural language.
d) Our approach needs closed world reasoning (e.g. checking the context of a user, in order to decide whether a preference is in effect). Therefore, it was selected instead of SWRL, because of the fact that SWRL employs open world reasoning without default negation.

e) It has better support by tools than RIF-PRD [30], which could have been used alternatively.

RuleML has to be translated into a machine executable language in order to be interpreted by the system. Jess was chosen for this purpose because it is a lightweight rule engine which matches well with web technologies [31]. Drools could have been used alternatively for this functionality [31]. It’s worth mentioning, that XSLT files [32] are used to transform RuleML rules to Jess rules.

Furthermore, common web technologies such Java Server Pages (JSP), HTML, JavaScript and AJAX used for visualization [33].

4 SYSTEM OPERATIONS

In this section an overview about system operations is included. The UML diagram in figure 1 displays the steps that have to be completed in order the system to execute the operations described below.

4.1 Data collection operation

The first operation that needs to be mentioned is data collection. To begin with user profile data, the system collects them through a registration form. All the properties are inferred dynamically by the schema.org ontology. Alternatively, users are able to connect Geo SPLIS with their Google+ account. If they chose this option, the system collects profile data from their account (name, job title etc.) through the available API. A mapping is done directly as Google+ property names are compatible with schema.org. Every time a user logs in with Google+, the system updates existing profile data. Regarding POI data collection, this is done by using Google Places API, as described in [13]. As mentioned above, all data are stored in RDF format in Sesame.

4.2 Presentation of Information operation

In order to deliver contextualized information, the system retrieves relevant data, evaluates rules and presents contextualized information.

4.2.1 Data retrieval

Data concerning user context (profile properties, relationships, rules, time, day, weather5) and data concerning nearby POIs (properties, owner, rules) are retrieved from the repository.

4.2.2 Rule evaluation

Data mentioned above are asserted to the Jess rule engine, which evaluates user’s rules (preferences) and places’ rules (POI owner group targeted offers) using the asserted data. Concerning user’s rules, Jess checks the conditions of a rule (they involve user contextual properties and place data) and concludes whether a place is relevant or not. The new derived information is fetched for presentation.

4.2.3 Presentation of personalized information

Finally, data are being transferred to the client for visualization of relevant places and personalized offers. Google Maps is the core component for illustration. A user-friendly interface has been implemented so that the user to be able to comprehend easily the general idea of Geo SPLIS and find quickly places that a) match his/her rules and b) contain offers associated to him/her. On the map presented in Geo SPLIS:

5 http://www.worldweatheronline.com/
• A bigger in size marker illustrates a POI which is relevant with user preferences and it is recommended.
• A green marker is used for a place which contains a rule base and at least one rule has been fired for the current user.
• A yellow marker indicates that the place contains a rule base of targeted offers but no rule is fired for the current user.
• A red marker represents a POI with no offers at all.
• A red star over the marker indicates that the current user is the owner of the specific POI.

Moreover, by clicking on a marker, apart from viewing place data, a user can contribute by a) writing a review, b) adding a rating, c) adding “likes”, or even d) making a check in. In other words, users do not only provide useful information to other people (e.g. to help them find a popular place) but they also create information that can be used during rule creation or rule evaluation (e.g. place average rating, number of likes). The system also provides the user with additional information explaining which rules were fired and why, based on his/her rules and rules from POI owners. In order to avoid confusion, a user rule/preference is illustrated with a person icon in front of the message and a POI owner rule is represented by a marker icon.

**Figure 1. Geo SPLIS operations’ steps.**

**4.3 Operations concerning rules**

POI owners and their operations are described in detail in [13]. In this section a detailed reference concerning user defined rules follows.

**4.3.1 Rule insertion through editor operation**

One of the core operations of the system is rule creation. By clicking on the menu “My rules”→“Add a rule” a user can directly add his/her own preferences. A user-friendly web interface has been designed so that users can easily add rules which pose conditions that relate their context with nearby POIs and offers. The web editor will be presented in detail with a use case scenario in the next section.

The rule that is created by the use of the web editor is transformed to RuleML syntax, for rule exchange purposes, and after that RuleML is transformed to the Jess rule language via xslt, in order to become machine executable. For example, table 1 illustrates the rule “If the day is Friday and time is before 17:00, I would like some museums”, in RuleML and Jess. Concerning Jess representation, the JESS salience operator is used for resolving rule conflict issues (in our case it is not necessary because there is no problem if two rules recommend the same POI) and “recommendation” is called the template which stores the POIs’ ids which result by the rule in case it is
fired. Moreover, “Explanation” is a variable for storing the explanation and presenting it to the end user.

Finally, rule data are stored in RDF triples format. Some of them are illustrated in Table 2. An extension has been made to the RDF/S ontology, by adding the corresponding policy class and its properties. In detail, it contains the following properties:

- “policy title”, which is a title for the rule
- “policy explanation”, a message explaining the rule
- “policy priority”, the priority of the rule
- “policy description”, a text which is automatically created from form data and is used for helping all users to understand the rule in case the creator inputs a non-comprehensible explanation message (or even no message at all).
- “policy_link”, a link containing the rule in RuleML syntax
- “policy_jess”, the rule in Jess syntax.

### 4.3.2 Rule update operation

By clicking on Geo SPLIS menu “My rules”Æ“Edit a rule”, a user can directly find all his/her preferences. He/she is able to modify or delete them by choosing the corresponding icon.

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<table>
<thead>
<tr>
<th>Table 1. RuleML and Jess representation</th>
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<tbody>
<tr>
<td><strong>RuleML representation</strong></td>
</tr>
<tr>
<td>&lt;?xml version=&quot;1.0&quot; encoding=&quot;UTF-8&quot;?&gt;</td>
</tr>
<tr>
<td>&lt;RuleML _&quot;&quot;&gt; &lt;Assert&gt; &lt;Rule style=&quot;active&quot;&gt; &lt;label&gt;drzgtgt &lt;/label&gt;</td>
</tr>
<tr>
<td>&lt;explanation&gt; If day is Friday and time is before 17:00, I would like some museums &lt;/explanation&gt;</td>
</tr>
<tr>
<td>&lt;if&gt; &lt;And&gt;</td>
</tr>
<tr>
<td>&lt;Atom&gt; &lt;Rel&gt;place&lt;/Rel&gt;</td>
</tr>
<tr>
<td>&lt;slot&gt;&lt;Ind&gt;type&lt;/Ind&gt; &lt;Ind&gt;Museum &lt;/Ind&gt; &lt;/slot&gt; &lt;slot&gt;&lt;Ind&gt;uri&lt;/Ind&gt;&lt;Var&gt;id&lt;/Var&gt;&lt;/slot&gt;</td>
</tr>
<tr>
<td>&lt;/Atom&gt;</td>
</tr>
<tr>
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</tr>
<tr>
<td>&lt;slot&gt; &lt;Ind&gt;day&lt;/Ind&gt; &lt;Ind&gt;friday&lt;/Ind&gt; &lt;/slot&gt; &lt;slot&gt;&lt;Ind&gt;time&lt;/Ind&gt;&lt;Var&gt;t&lt;/Var&gt;&lt;/slot&gt;</td>
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<tr>
<td>&lt;/Atom&gt; &lt;Expr&gt;&lt;Fun&gt;&lt;&lt;/Fun&gt;&lt;Var&gt;t&lt;/Var&gt;&lt;Ind&gt;17&lt;/Ind&gt;&lt;/Expr&gt;</td>
</tr>
<tr>
<td>&lt;/And&gt; &lt;/if&gt;</td>
</tr>
<tr>
<td>&lt;then&gt; &lt;Assert&gt;</td>
</tr>
<tr>
<td>&lt;Atom&gt; &lt;Rel&gt;recommendation&lt;/Rel&gt;&lt;slot&gt;&lt;Ind&gt;id&lt;/Ind&gt;&lt;Var&gt;id&lt;/Var&gt;&lt;/slot&gt; &lt;/Atom&gt;</td>
</tr>
<tr>
<td>&lt;Assert&gt;&lt;/then&gt;</td>
</tr>
<tr>
<td>&lt;/Rule&gt;&lt;/Assert&lt;/RuleML&gt;</td>
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<table>
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<tr>
<th>Jess representation</th>
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<tbody>
<tr>
<td>(defrule kctysfvn</td>
</tr>
<tr>
<td>(declare (salience 1)) (place ( type Museum) ( uri ?id)) (person ( day friday) ( time ?t) ) (test (&lt; ?t 17)) =&gt; (assert (recommendation( id ?id))) (store EXPLANATION &quot; If day is Friday and time is before 17:00, I would like some museums &quot;)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2. Rule data in RDF format</th>
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<tbody>
<tr>
<td><a href="http://schema.org/policy19d883ef-f735-4521-a8a6-771165b1b2a8">http://schema.org/policy19d883ef-f735-4521-a8a6-771165b1b2a8</a></td>
</tr>
<tr>
<td>&quot;IF person:time &lt; 17 AND person:day is Friday THEN I WOULD LIKE TO GO TO A place:type Museum&quot;</td>
</tr>
<tr>
<td><a href="http://schema.org/policy19d883ef-f735-4521-a8a6-771165b1b2a8">http://schema.org/policy19d883ef-f735-4521-a8a6-771165b1b2a8</a></td>
</tr>
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<td>&quot;1&quot;</td>
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execute these rules on the fly.

SPLIS parses the RuleML files, converts them to Jess and then user logs into Geo SPLIS with his/her Google+ account, Geo SPLIS’s web editor and receive the RuleML link. Finally, after a users have difficulties in authoring such rules, they can use Geo SPLIS’s web editor and receive the RuleML link. Finally, after a user logs into Geo SPLIS with his/her Google+ account, Geo SPLIS parses the RuleML files, converts them to Jess and then execute these rules on the fly.

Another operation which has been implemented is the connection with Google+ and the capability to retrieve rules through it. Google+ was chosen because it is compatible with the scema.org ontology and offers to the user the capability to add links (actually a url and a label describing it) to his/her profile. Furthermore, these links are available to other services through the corresponding API, just as the other profile properties. Thus, it is possible for a user to upload a RuleML link to his/her profile (containing rules in the format illustrated above), set as label the tag “policy_link” and then share his/her preferences with other services. This functionality has been implemented in order to demonstrate how social network profiles could be enhanced and contain information which represents something further than simple data (in our case contextualized preferences concerning POIs). In addition, if users have difficulties in authoring such rules, they can use Geo SPLIS’s web editor and receive the RuleML link. Finally, after a user logs into Geo SPLIS with his/her Google+ account, Geo SPLIS parses the RuleML files, converts them to Jess and then execute these rules on the fly.

4.3.4 “Get a rule” operation

Beyond rule creation, users are also encouraged to get rules from other users. First of all, they are able to search among existing rules. For example they can search for rules concerning tags “Restaurant”, “Saturday”, etc. A list including all existing rules matching their criteria is displayed and they are capable of getting them by clicking the “Get it!” button. Additionally, as soon as they log in, next to the map, the 3 most popular rules are displayed in order to be easy to get some of them. Furthermore, after they “check in” in a POI or “like” it, a list of the 5 most popular rules concerning the corresponding contextual condition is displayed in a pop up window (e.g. if they “like” a restaurant, the 5 most popular rules concerning restaurants will be displayed). To avoid confusion in rule update process (consider for example a scenario where a user A gets a rule and then modifies it), as soon as a user updates a rule, a new rule is created. If a user deletes a rule, he/she is simply “unlinked” from the rule so as not to affect other users that have this rule. A rule is deleted if no one else possesses it.

4.4 Planning operation

Another implemented operation in Geo SPLIS is the planning mode. By clicking on “Planning” button on the Geo SPLIS menu, a pop up window appears including two drop down menus which concern the day and the time that the user plans to visit a location. More specifically, he/she can chose after how many days he/she will visit a location and the time that he/she will be there. The system gets user’s future context (day, time, weather) and evaluates his/her rules and POI targeted offers depending on this context. It is worth mentioning that a) by right clicking on the map they can change the location that they plan to visit and b) the number of future days is restricted to 5 due to available future weather information. This operation is illustrated with a use case scenario in the next section.

5 USE CASE SCENARIOS

A use case scenario concerning a random user is presented in this section in order to demonstrate Geo SPLIS capabilities. The scenario considers a user called “Mary” who is a 20-years old female student.

5.1 Scenario concerning rule addition through the editor

Let’s assume that Mary has used the web editor and inserted the rule “If day is Wednesday and time is between 12:00-17:00, then I would like some museums”. The corresponding rule is represented in the editor as displayed in figure 2 below. To begin with, the web interface provides fields for entering the title and the priority of the rule. By clicking on the yellow info (!) icon, Mary can get a helpful comment for each field. Above those fields, there are the four “Add …. Condition” buttons. By clicking each one of them, she is able to customize the corresponding contextual condition. For example, she adds a preference concerning time condition by clicking the “Add Time Condition” button. The condition customization consists of three elements:

a) The property field (weather, day, time, distance).
b) The operator field (“is” for day and weather and “<”, “>” for time and distance).
c) The value.

Elements concerning properties and operators are represented by read-only texts and value elements by drop down menus. This approach is adopted to resolve user data heterogeneity and eliminate any mistakes, something essential in user defined rules. By repeating this process she can add as many conditions as she likes. An “AND” is implied among them. By clicking on the red (x) button that exist next to every condition (see figure 2), the user can delete a condition.
After finishing with context conditions she has to choose the desired place type by clicking on the related drop down menu. It’s worth mentioning that schema.org hierarchy is adopted in this menu. For example, if she chooses the place type “Store” all its subcategories are included (e.g. GroceryStore etc.). Moreover, by clicking on the “Add Where Condition” button she is able to add more conditions regarding desired POI properties. A property drop down menu, an operator drop down menu (“is” and “contains” for text and “<”, “>” for numbers and dates) and a value field are included.

The last step for Mary is to add a textual explanation for the rule, so that the meaning of the rule to become clear to her and to other users. A preview of the created rule is also provided, displaying its description (see policy description property above), so as she can check the rule before submitting it to the rule base. Additionally a clear button exists for clearing all the forms and resetting the process. Last but not least, in order to help her understand the process and save time, she is able to click on one of the most popular rules in the left side of the screen and the forms concerning this rule are automatically filled.

5.2 Scenario concerning rule addition through the Google+

Let us now consider an alternative scenario about user “Mary”. In this scenario, she has a RuleML file which contains her rule-based preference. We assume that it contains the RuleML which is illustrated in table 1 above (this file is saved at http://platon.econ.auth.gr/examples/plis_new_users/files/policy19d883ef-f735-4521-a8a6-771165b1b2a8.ruleml) and represents the rule “If day is Friday and time is before 17:00, I would like some museums”. As it was discussed above, by visiting her profile page on Google+ Mary is able to add this link and set as label the text “policy_link” (see figure 3). In this way Geo SPLIS, or other services compatible with schema.org, could exploit these rules. Every time she logs in Geo SPLIS with her Google+ account, Geo SPLIS crawls her page, parses the rules and evaluates them on the fly.

Figure 2. Adding a rule with the web editor

Figure 3. Adding a rule to Google+ profile page
5.3 Scenario concerning contextualized information

After that, we assume that Mary (which possesses the rules described in scenarios 5.1 and 5.2 above) logs into Geo SPLIS with her Google+ account on Wednesday, at 14:25 in a location A where the weather is sunny. As it was discussed above, after a user is inserted into Geo SPLIS, it evaluates his/her rules/preferences and nearby POIs’ rules/group targeted offers and delivers personalized information. Considering Mary, the rule “If day is Wednesday and time is between 12:00-17:00” (presented in scenario 5.1 above) is fired, because it is Wednesday and time is 14:25. Consequently, all the available restaurants are represented with a bigger marker and are recommended to her (figure 4 below). In order to help her find easier a POI category, the marker contains the first letter of the category it belongs (e.g. “R” for restaurants). She can directly click on the markers and find POIs and offers related to her contextual situation. By clicking on a big green marker she can find a restaurant which also has an offer for her. Taking for example the POI “Nama” (figure 5a) which is represented with a big green marker, she is able to view its properties (e.g. cuisine, telephone etc.). It’s worth mentioning that spaghetti price is represented with an orange font because its value was modified by the POI owner’s (fired) rule. In the same window, after the appearance of the properties, the POI owner’s message for the group targeted offer that matches her profile is presented. Finally, her rule which was fired and recommended this place is displayed. Apart from viewing information, she can add a “like”, a review etc. as referred above. Similarly, if she clicks on “Pizza Greca” (is represented with a big yellow marker) she can get the personalized info illustrated in figure 5b. According to this, Mary is entitled for the standard pizza price and the POI’s rule is not fired for her (she is not unemployed and day is not Saturday). She also gets explanations concerning all the POI’s offers so as to understand what kind of rules constitute the offering policy of this place and the reason(s) why they were not fired for her.

Notice that in the left side of the screen, by checking the corresponding explanations, she can directly get some of the three most popular rules of all users.

Figure 4. Geo SPLIS - Mary’s starting screen

Figure 5. Personalized information for Mary
5.4 Scenario concerning planning operation

Let’s now consider an alternative scenario. Mary will visit Rome on Friday afternoon and would like to get some information about POIs and offers there. In order to achieve this, she clicks the “Planning” button from Geo SPLIS menu and in the pop up window she selects a) the option after 2 days, b) the time she will be there (13:00 in our scenario). As soon as she is inserted into planning mode she can right click on the map in Rome and find places and offers matching a) his/her rule based preferences and b) POIs’ rules for the future situation (figure 6). Because of the fact that it is Friday and time is 13:00 o’clock, the rule “If day is Friday and time is before 17:00, I would like some museums”, which was presented in scenario 5.2, is fired. Consequently, museums are represented with a bigger marker. By clicking on the markers she can get future, contextualized information (finding offers which are valid for her, when she will be there).

6 EVALUATION

In order to evaluate the system, a quantitative approach was followed. Geo SPLIS, shown in figure 7a, is compared with a stripped-down version of Geo SPLIS, shown in figure 7b, which has only red and yellow markers. A red marker indicates that a place does not have any offers and a yellow marker indicates that a place has at least one offer, which may matches user profile. The stripped-down version of Geo SPLIS does not have green markers, to indicate that least one rule has been fired for the current user. The user of the stripped-down version of Geo SPLIS had to click on a marker and a) view POI’s category so as to understand if it matches his/her preference and b) read POI owner’s message to understand if their offers matches his/her profile or not. After a short introduction to the two systems, the users were informed that they should imagine that they have the following rule based preference: “If day is Wednesday, find me some Coffee shops” (the evaluation took place on Wednesdays so the rule was fired). In Geo SPLIS this rule has been added in advance while in the stripped-down version it was told to the users just before they started to use the system. 44 undergraduate students of Economics (18-22 years old, both genders) took part and they performed the following 3 tasks, first to the stripped-down version of Geo SPLIS and after that to Geo SPLIS:

Task1. Find how many places match with your preference and contain an offer which also matches with your profile.

Task2. Find how many places contain an offer which matches with your profile.

Task3. Find how many places match with your preference and contain an offer that does not match with your profile.

These tasks were performed in different areas on the map and had equal number of solutions so as the experiment to be fair. In detail, the map included:

- 25 places
- 2 places/solutions to Task 1
- 6 places/solutions to Task 2
- 3 places/solutions to Task 3
Figure 7. Illustration of the compared systems

Figure 8 below demonstrates the average and median time (in seconds) required for completing each task, concerning the two systems. As can be observed, Geo SPLIS performed better in all tasks, assisting the users in completing the tasks notably sooner. In order to assess whether the differences in times are statistically significant, one-way ANOVA was conducted on the median times for completing each task. Median time was used to eliminate the effect of outliers. The two systems are statistically different if the factor p-significant of the ANOVA test is lower than 0.05. As illustrated in Table 3, there is a statistically significant difference in median times because p value was found equal to 0.00131 that is much less than 0.05.

Figure 8. Median and average time (in seconds) required for completing each task, concerning the two systems

<table>
<thead>
<tr>
<th>Approach</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F</th>
<th>p-significance</th>
</tr>
</thead>
<tbody>
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<td>1098.771</td>
<td>64.120</td>
<td>0.00131</td>
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<tr>
<td>Within approaches</td>
<td>68.543</td>
<td>17.135</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. One-way ANOVA results
7 CONCLUSIONS AND FUTURE WORK
In this work, an innovative knowledge-based LBS, called Geo SPLIS, was presented. Geo SPLIS provides semantic based contextualized information by modeling regular users’ contextualized, rule based preferences and connecting them with POI owners’ group-targeted offering policies. On the one hand, regular users enjoy proactively POIs and offers depending on their preferences and their contextual situation, and on the other, POI owners (by being able to specify their offering policy rules) can exhibit a highly targeted marketing strategy by reaching their potential customers right on time. In order to achieve all the above, Geo SPLIS:

a) Collects data from external sources such as Google Places API, POIs’ websites and Google+ accounts.

b) Adopts a novel, widely accepted ontology such as schema.org to represent persons’ profiles, POIs and their relations.

c) Offers users and POI owners the capability to create rules at run time by providing a user friendly web based editor.

d) Transforms these rules into RuleML format, in order to be shared by other systems in the web, and then into Jess inference engine so as to be machine executable.

e) Stores metadata and rules in the form of RDF triples (using the Sesame repository) for knowledge sharing and reusability.

f) Displays personalized information on Google Maps.

Geo SPLIS evaluation show that the capability of having a dynamic knowledge base (by enabling non technical run time users to add data and rules) can provide qualitative contextualized information and overcome some of the disadvantages of rule based systems such as that:

a) Their knowledge base contains a predefined set of rules, which cannot describe every possible situation.

b) Rule creation and modification is a time consuming process for the developers.

c) Developers’ rules are not always efficient for every user or every situation.

Moreover, experimental testing results confirmed Geo SPLIS contribution demonstrating how easy was for users to find places and offers matching their context.

Engaging non technical users to generate content is a great challenge and previous Web 2.0 collaborative content creation platforms (e.g. YouTube, Twitter) demonstrate that this is possible.

Geo SPLIS implementation can evolve in the future in various ways. One future direction will be the addition of a social layer. This could be implemented by adding social relations and connect a user with his/her nearby friends (e.g. execute all their rule base preferences and find common places). In addition to this, other social media sources such as Facebook, Twitter etc., will be integrated. Furthermore, a mobile application for devices that support Android operating system will be implemented.

8 REFERENCES


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